Virtual Neuromuscular Training to Reduce Injury Risk After Concussion: A Pilot Study in Healthy Adults

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Background
- Sports-related concussion is associated with an increased risk of musculoskeletal injury following return-to-play
- Current return-to-play strategies may ineffectively meet the complex cognitive and motor demands of sport
- Interventions affecting neuromuscular control may reduce injury risk after concussion.

Purpose: To determine the feasibility and associated changes that occurred with an 8-week virtual Neuromuscular Training (vNMT) program using a novel, smartphone-based platform in healthy adults.

Virtual Smartphone Platform

Figure 1. Screenshots from the IMPROVE application on a smartphone device

Figure 2. Study Flow Diagram

Methods
- Initial Visit
- 8 weeks
- Follow-Up Visit

Table 1. Description of self-reported and clinician-obtained performance measures.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
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<tr>
<td>Sleep Quality (PSQI)</td>
<td>The Pittsburgh Sleep Quality Inventory is a validated scale to calculate sleep duration and elements contributing to overall sleep quality.</td>
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<tr>
<td>Confidence in Movement Scale</td>
<td>The Adolescent Measure of Confidence and Musculoskeletal Performance is a validated measure used to assess confidence in movement abilities following injury.</td>
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<td>Dizziness Handicap Index</td>
<td>Identifies problems related to dizziness in everyday life.</td>
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<td>Tampa Scale of Kinesiophobia</td>
<td>A valid outcome measure used to identify post-concussion fear of pain with movement.</td>
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<tr>
<td>GAD-7</td>
<td>The Generalized Anxiety Disorder-7 is used as a brief screening tool and severity measure for GAD.</td>
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Self-Reported Measures
- Participants walk heel-to-toe, as quickly as possible, along a 3 meter strip of tape, make a 180-degree turn at the end of the tape and return to the starting point with the same heel-to-toe gait. In the dual-task condition, participants complete a cognitive task while simultaneously walking heel-to-toe.

Clinician Obtained Measures
- Balance Error Scoring System is a static balance assessment performed under 2 stance conditions: single-leg and tandem stance.
- Reaction time (RT) | Reaction time was measured using both drop stick and smartphone techniques. Drop stick RT measures time required to catch a suspended vertical shaft while hand closure. Smartphone RT measures the speed at which patients respond to a simple on-screen stimulus.
- Triple hop test | Participants perform a triple hop for distance test by performing 3 consecutive maximal single leg hops forward on each limb. |
- Multiple hop test | Participants perform multiple hop test to assess dynamic postural control by hopping with their dominant limb along a multi-directional pattern of ten floor markers.

Results
- At the time of analysis, n=18 participants had completed both pre and post intervention visits:
  - 8 vNMT (24.9±1.1 years; 75% female)
  - 10 control (26.4±3.0 years; 70% female)
- We observed no significant between-group differences for any measurement obtained:
  - This was somewhat expected, given we were testing non-impaired individuals
- The vNMT group demonstrated fewer errors in the multiple hop test at the post-intervention assessment compared to the control group, although this did not reach statistical significance:
  - Pre-intervention errors: vNMT=2.2(1.3), Control=2.2(1.3); p=0.97
  - Post-intervention errors: vNMT=1.0(0.8), Control=2.1(1.3); p=0.10
  - Cohen’s d = 0.84

Implications
- Necessary first step in assessing the efficacy of a smartphone-based rehab program in a healthy population
- Goal: To shift clinical practice by integrating this model into concussion management to reduce musculoskeletal injuries following return-to-sport after concussion

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